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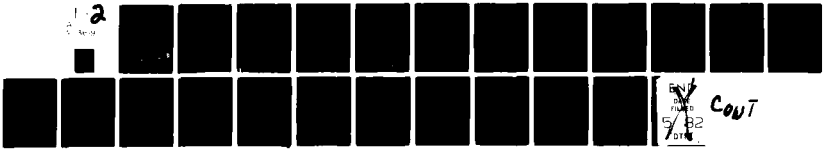

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Evaluation of Distribution and Display Systems for Satellite Imagery (Phase I)

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March 1982

Interim Report

U.S. Department of Transportation
Federal Aviation Administration
Systems Research & Development Service
Washington, D.C. 20590

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16. Abstract

This in-house study was conducted to determine the acceptability and operational effectiveness of an experimental system for displaying and distributing satellite imagery designed for flight service station (FSS) application. Primarily, consideration was given to the efficacy of the displayed data, together with the presentation format used for the demonstration. Secondly, man-machine relationship and some software aspects were tested and evaluated.

Interim results indicate that the prototype system provided graphic data in a form suitable for use by preflight, in-flight, and en route flight advisory specialists for nearly all their briefing functions. Equipment configuration, assembled for this evaluation/demonstration, proved reliable and acceptable (though not necessarily optimal) by the specialists participating in the demonstration. Conditional acceptability included display medium and size, graphical quality and information presentation, and associated software programs for accessing the data through the prototype system. It is recommended that a field study be conducted as Phase II of this evaluation.

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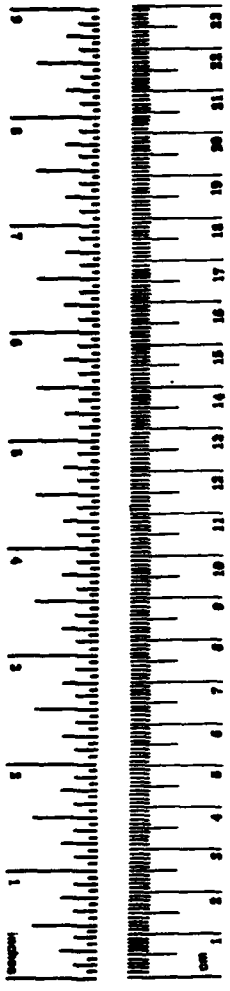
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

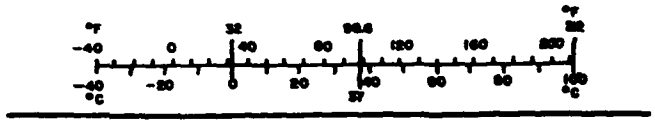
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

This report presents an evaluation of methods used for distribution, storage, and display of satellite pictorial products in the Model 2 Flight Service Automation System. Project objectives include the test and evaluation of currently available data, presentation methods, operational procedures, and system configurations. In accomplishing these objectives, the question of cathode-ray tube (CRT) versus hardcopy display of weather products is addressed. Additionally, the CRT display, with enhancements to demonstrate its suitability as a tool in the Flight Service Station (FSS) briefing function, was investigated.

Results of this phase I study have shown the preference for and complete adequacy of the CRT display of satellite images over that of contemporary hardcopy. In addition, digitally enhanced infrared images were preferred, together with the capability to project these images at medium speed, slow speed, and individually (step feature); the speed depending on the specialist's current requirements. Finally, and most importantly, the animation feature was the most praised and desired of all features demonstrated which utilized the Geostationary Operational Environmental Satellite (GOES) system products.

It was concluded that the proposed satellite image display system was a more effective tool when augmented by other information and products for overall briefing effectiveness. Hence, it is recommended that a phase II field test be conducted for further system developmental input.

INTRODUCTION

PURPOSE.

The purpose of the test was to evaluate methods for the distribution and display of satellite pictorial products, as set forth in the specifications for the Model 2 Flight Service Information System Automation Program.

BACKGROUND.

As part of the Flight Service Automation System (FSAS), a preliminary evaluation of a prototype distribution and display system for weather satellite images from the Geostationary Operational Environmental Satellite (GOES) system was conducted at the Federal Aviation Administration (FAA) Technical Center by personnel of the Flight Service Station Branch (ACT-250) during the period September 4, 1980, to October 17, 1980, utilizing 24 field Flight Service Station (FSS) personnel from all regions within the FAA.

SYSTEM DESCRIPTION.

The engineering model being used for phase I, in-house evaluation, automatically and continuously receives, stores, and processes satellite images which are transmitted over telephone lines to the subscriber.

The recorder stores images in standard television format. A total of 96 images are recorded, two per hour, with only the last 48 hours being retained in a dual-loop pictorial record. As each new image is processed and recorded, the oldest image in the appropriate loop is deleted. Hence, the recorder stores the images on two "movie loop" tracks.

The user/specialist can view the stored images in many different ways. That is, the entire 48 hours as a "movie" can be reviewed, played forward or backward at one of the three sequencing rates, or played through forward or backward, image-by-image, allowing "stop action" on any image.

Other special features allow the specialist to display a partial loop containing the latest 6 hours of images. Also, the most current image can be called up using the STILL (ST) display command. Sectorization, although not fully developed, will offer the operator a 3-to-1 blowup of preselected images.

FUNCTIONS AND FEATURES. The program written for the in-house phase I evaluation of the GOES Distribution and Display System (GDDS) enables the user to move freely within the systems software framework regardless of where he enters or where he is in the program. Only the first two letters of each command word are required to access a feature of the system. Also, the whole word or any part (in excess of two characters) may be entered — this will get the operator into the program. All commands are executed by the system when the "Return" key is depressed; that is, the command sequence is not completed until the "Return" function is keyed. The command functions are as follows:

1. Types of imagery displayed.

a. INFRARED (IR) - displays digitally enhanced and standard infrared images which are received on the hour from "Loop 1."

b. VISUAL (VI) - displays visual satellite images collected on the half hour; however, all night images received on the half hour will be IR and are placed on the VI loop (LOOP 2).

c. BOTH (BO) - causes consecutively displayed images to come alternately from IR (LOOP 1), then VI (LOOP 2), etc., causing the recorder to operate as a single loop device. In order to back the system out of the BO mode, the operator must key in an IR or VI command function.

2. Quantity of images available in sequence.

a. PARTIAL (PA) - displays the most current images of the selected type received in the last 4 or 8 hours (16 images in the BO mode; 8 images in Loop 1 or Loop 2 mode).

b. FULL (FU) - causes all images of the selected type to be presented (96 images in the BO mode; 48 images in Loop 1 or Loop 2).

3. Viewing mode.

a. STILL (ST) - causes the display to stop and display the most current image in the loop of the type of image previously selected when this mode is entered.

b. ANIMATED (AN) - causes the presently selected rack of images to be displayed in an animated and forward sequencing mode at a specified rate (FAST, MEDIUM, SLOW).

4. Other.

a. FORWARD (FO) - causes the currently selected rack to be displayed or sequenced in the forward mode.

b. REVERSE (RE) - causes the currently selected rack to be displayed in a backwards (reversed order) time or "stop action" playback at any selected rate.

c. HALT (HA) - causes the animated display to stop and enter the single step mode. It is suggested that this function be used when scanning for a specific image; enter HA, when the desired images appears on the display key in the (CR) function to execute the command. If the system overruns the desired image, it is easily retrieved by using the FO/RE commands.

EQUIPMENT INSTALLATION.

Animation and display of GOES imagery was obtained by the use of an Information Processing Systems (IPS) video disc unit. This device was controlled by an Interdata 7/32 minicomputer.

The IPS unit received its satellite imagery input from a half-duplex C-2 conditioned data circuit. No control of images received at the test site was possible owing to the nature of this line. Incoming images received between 5 minutes before and 25 minutes past the hour were stored on "Loop 2" of the IPS unit and were, in general, digitally enhanced, stretched gray scale, infrared products. Those images received between 25 minutes and 55 minutes past the hour were stored on "Loop 1" of the IPS unit and were generally visual images for daylight hours and unmodified infrared during the nighttime period. Forty-eight images could be stored on each track.

The video disc also served to convert the GOES information from the audio to the video domain via a digital scan rate conversion technique. Excessive information for video display was also rejected during the conversion. The resulting product of the conversion process was stored on the video disc in analog format.

The display device employed for the test was a 14-inch diagonal measure P43 phosphor CRT display. The unit was not selected as an optimum display device. The choice was determined by the availability of monitors during the test period. This display also functioned as a feedback device to the subject. Switching between the two modes of operations was achieved via a manual switch located at the test position.

Operator input was by means of a standard ACSII keyboard connected via an EIA standard RS-232C channel to host computer. A control program decoded the operator's simple English commands and sent the corresponding command code sequence to the IPS unit. The control link between the video disc and the host computer was half duplex, EIA standard RS-232C.

SYSTEM EVALUATION

MAJOR LIMITATION OF THE EVALUATION.

All test subjects were experienced journeymen flight service station specialists with an approximate equal mix of subjects from automated and nonautomated flight service stations. However, to enable the reader to judge the validity of the conclusions reported from the data and the general value of the evaluation, it is important to point out the following major limitation. Of the 24 specialists selected, only three specialists had formal training in satellite imagery interpretation, and just two were utilizing this training and the GOES products in their home facilities. However, it was felt that their evaluation of the proposed system and concept would be of distinct value in light of their substantial FSS experience and weather knowledge.

EVALUATION PROCEDURES.

The GOES system evaluation period took approximately 2 hours, and included a specialist questionnaire (appendix A) and interviews by a project evaluation team member (appendix B). The intent of the interview was to be an open forum for the evaluating specialist to discuss with a Technical Center engineering research psychologist and a senior project FSS specialist, his impression of the GOES images as a tool for use in FSS pilot briefings. Comments were also solicited on improving the proposed system.

Data collected included both an engineering evaluation of equipment and a user evaluation of display techniques and products. In addition, since the requirement to interface with existing and planned operational displays was imposed on the system design, data collection and analysis addressed how well the operational and human factors aspects were handled.

USER EVALUATION. The user evaluation was conducted in as realistic a setting as possible, utilizing FSS journeyman specialists from the field to evaluate the system. Specifically, 24 specialists of various background, training levels, and facilities (Levels I, II, and III) were shown contemporary satellite products and were then asked to evaluate those products observed with the display system assembled for this study.

The specialist filled out a questionnaire for the purpose of evaluating both display types and methods. This was followed, where appropriate, based on GOES training and field facility; i.e., automated or manual, by a personal interview for the purpose of obtaining a general assessment of the GOES products and displays. Project personnel were also available to assist the specialists during the evaluation and to make observations. In this capacity, Technical Center project personnel documented their own comments and those comments made by the specialists during the test evaluation period. They also noted suggestions made by the specialists. These comments, suggestions, and observations were considered when evaluating test data and formulating test results.

ENGINEERING EVALUATION. The engineering evaluation and questionnaire data of an objective multiple-choice nature were collected, summed, and subjected to appropriate statistical analysis. And finally, the collected questionnaire and interview data of a subjective nature were ranked and a rank-order correlation was derived for specialist preferences.

Table 1 is a tabulation of the responses to the GOES System Specialist Opinion Survey form. The form used is shown in figure 1. This survey is a qualitative comparison between the contemporary means of receiving and displaying these products and the proposed video displays. Following a demonstration and hands-on experience with the prototype system, the specialists would express their opinion on aspect items of the survey form as to whether a particular aspect was an improvement, remained the same, or if the present system was better.

STATISTICAL ANALYSIS.

To accomplish the statistical analysis, the following integer numerical values were assigned to the five choices on the opinion survey: vast improvement (5), improvement (4), no change (3), present system is better (2), present system is much better (1). The number of responses within each choice category was weighted by the value of the category and combined using standard statistical methods. A mean and standard-error-of-the-mean were computed for each of the aspects within each of the data sets. Student's "t" tests were performed to determine the statistical significance of the deviation of the mean response from the center of the scale (3 = no change). For those aspects whose means were significantly below 3.0, the consensus of specialists was that the present system was better. If the mean fell significantly above 3.0, an improvement in that aspect was noted. Unless otherwise noted, a confidence level of alpha, equal to or less than 0.05, was used to determine significance of the t score. Since there was

Aspect On Which Comparison Is To Be Made	Compared to contemporary products that you are presently using for the display of satellite images, how would you rate the video display of these satellite images as observed in this evaluation?				
Rating Scale (Check One Column For Each Question Which Best Expresses Your Opinion)	Vast Improvement	Improvement	No Change	Present System Better	Present System Is Much Better
1. Speed of data access					
2. Ease of obtaining data					
3. Time required to perform pre/post-duty briefing					
4. Thoroughness in presenting data for briefing					
5. Ease of extracting and interpreting information					
6. Ability to obtain and understand the overall weather situation					
7. Confidence in system					
8. Overall ability to give adequate and complete briefing					
9. Ability to self-brief prior to taking the position					
10. Time require to disseminate information					
11. Clarity of the information displayed					
12. Ability to adequately explain the weather					
13. Effect on integrating satellite information with other briefing products					
14. Amount of eyestrain					
15. Suitability of display as an information source					

FIGURE 1. GOES SYSTEM SPECIALIST OPINION SURVEY FORM

TABLE 1. GOES SYSTEM — SPECIALIST OPINION SURVEY

	Aspect Item On Which Comparison Is To Be Made	Number of Respondents (N = 24) *	Vast Improvement	Improvement	No Change	Present System Better	Present System Is Much Better
1.	Speed of data access	21	18	3	0	0	0
2.	Ease of obtaining data	21	14	7	0	0	0
3.	Time required to perform pre/post-duty briefing	21	12	7	2	0	0
4.	Thoroughness in presenting data for briefing	21	12	8	1	0	0
5.	Ease of extracting and interpreting information	21	12	5	4	0	0
6.	Ability to obtain and understand the overall weather situation	21	11	9	1	0	0
7.	Confidence in system	21	10	7	4	0	0
8.	Overall ability to give adequate and complete briefing	21	8	10	3	0	0
9.	Ability to self-brief prior to taking the position	21	9	11	1	0	0
10.	Time require to disseminate information	21	10	8	3	0	0
11.	Clarity of the information displayed	21	6	8	5	2	0
12.	Ability to adequately explain the weather	21	9	9	3	0	0
13.	Effect on integrating satellite information with other briefing products	21	11	8	2	0	0
14.	Amount of eyestrain	20	2	6	9	3	0
15.	Suitability of display as an information source	21	9	11	1	0	0

*Three specialists did not respond to questions 1 through 13 and 15.

Four specialists did not respond to question 14.

no a priori reason to expect deviations from the mean in only a single direction, two-tailed tests were used for all items. All questions were phrased so that careful reading would result in fair responses, thus precluding stereotype answers. Also, response categories were varied so as to minimize common sources of error, such that no response was unduly influenced by a single or overall favorable aspect when rating dimensions. That is, the form was designed so the respondents would read and respond to each item independent of the previous item or any overall attitude toward an automated system.

The strong preference for such a display system is profoundly evident from the statistical results presented in tables 2 and 3. Although the questions were phrased to include a balance of favorable or unfavorable responses, the interpreted value of the changes was positive over 93 percent of the survey. The aspect item that yielded the highest t score was item 1 (speed of data access).

SUMMARY OF RESPONSES.

RESPONSES FROM GOES SYSTEM EVALUATION QUESTIONNAIRES.

1. Do you prefer machine display (as in the IPS) or hardcopy display of satellite weather information for use in pilot briefings?

Machine display, utilizing CRT's, was the overwhelming choice as a display medium. Hardcopy had a singular benefit mentioned by several specialists; namely, increased clarity especially on the visual images. But, even with this benefit, those specialists prefer machine display when looking at the total system utilization. Pertinent comments were as follows:

"The machine display is much better suited for pilot briefings because of the looping capabilities, ease in accessibility, and simple operational codings."

"I feel the IPS (machine display under evaluation) is better suited for briefings as it is much easier to show a trend and has an easier access to weather data."

"Machine display does not have the clarity of hardcopy, particularly with visual (VI) imagery. However, advantages of machine display; i.e., "movie loop," outweigh this factor."

"I prefer a machine system. In normal situation, the hardcopies float around various positions making access difficult, if not impossible."

2. Can you adequately use the machine display medium in the performance of your duties at preflight...at in-flight...at EFAS?

Response to this question was mixed: 73 percent said "Yes;" 9 percent said "No;" and 18 percent gave a conditional, but qualified "Yes." The "no" responses were due to lack of training/familiarization associated with interpreting satellite imagery.

Responses were highly favorable at the preflight position (100 percent), especially in face-to-face briefings. Responses were somewhat negative at in-flight and EFAS. As one GOES system trained specialist said, "Real-time demands

TABLE 2. T SCORE ANALYSIS, PART I

Aspect Item On Which Comparison Is To Be Made	Mean X	Standard Deviation SD	Standard Error SE	T-Score	Significance
1. Speed of data access	4.86	0.359	0.078	+23.81	0.05
2. Ease of obtaining data	4.67	.483	.105	+15.87	.05
3. Time required to perform pre/post-duty briefing	4.48	.680	.148	+9.97	.05
4. Thoroughness in presenting data for briefing	4.52	.602	.131	+11.63	.05
5. Ease of extracting and interpreting information	4.38	.805	.176	+7.85	.05
6. Ability to obtain and understand the overall weather situation	4.48	.602	.131	+11.27	.05
7. Confidence in system	4.29	.784	.171	+7.52	.05
8. Overall ability to give adequate and complete briefing	4.24	.700	.153	+8.09	.05
9. Ability to self-brief prior to taking the position	4.38	.590	.129	+10.71	.05
10. Time require to disseminate information	4.33	.730	.159	+8.39	.05
11. Clarity of the information displayed	3.86	.964	.210	+4.08	.05
12. Ability to adequately explain the weather	4.29	.717	.157	+8.18	.05
13. Effect on integrating satellite information with other briefing products	4.43	.676	.148	+9.65	.05
14. Amount of eyestrain	3.35	.875	.196	+1.79	.05
15. Suitability of display as an information source	4.38	.590	.129	+10.71	.05

TABLE 3. T SCORE ANALYSIS, PART II

	Aspect Item On Which Comparison Is To Be Made	Perceived Change	Perceived Value of Change	Rank	T-Score
1.	Speed of data access	IMPROVEMENT	*	1	-23.87
2.	Ease of obtaining data	IMPROVEMENT	*	2	-15.87
3.	Time required to perform pre/post-duty briefing	IMPROVEMENT	*	7	- 9.97
4.	Thoroughness in presenting data for briefing	IMPROVEMENT	*	3	-11.27
5.	Ease of extracting and interpreting information	IMPROVEMENT	*	12	- 7.52
6.	Ability to obtain and understand the overall weather situation	IMPROVEMENT	*	4	-11.27
7.	Confidence in system	IMPROVEMENT	*	13	- 7.52
8.	Overall ability to give adequate and complete briefing	IMPROVEMENT	*	11	- 8.09
9.	Ability to self-brief prior to taking the position	IMPROVEMENT	*	5	-10.71
10.	Time require to disseminate information	IMPROVEMENT	*	9	- 8.39
11.	Clarity of the information displayed	IMPROVEMENT	*	14	- 4.08
12.	Ability to adequately explain the weather	IMPROVEMENT	*	10	- 8.18
13.	Effect on integrating satellite information with other briefing products	IMPROVEMENT	*	8	- 9.65
14.	Amount of eyestrain	***	**	15	- 1.79
15.	Suitability of display as an information source	IMPROVEMENT	*	6	-10.71

* Respondents Favor Video Display System
** Respondents Favor Current System
*** The difference is not statistically reliable; therefore, we cannot offer any compelling evidence at this time that there is any profound difference in item 14 relative to either system.

were not met." The greatest value seemed to be in the specialist self-briefing for an overall view of the weather trend. In addition, it was felt that GOES product could be effectively used at all positions and would augment weather graphical products; e.g., surface analysis charts.

3. What is your reaction to the system's capability to update satellite images?

Responses ranged from "very good" to "excellent." Update prior to machine display was left to comparison only. In utilizing the CRT, the movement leaves little doubt.

4. What is your reaction to the sequencing capability of the system? Do the animated displays assist you in weather trending?

The animation feature was the most highly praised feature identified in this GOES evaluation. The animation and the capability to control one's own pace utilizing the step mode were the major advantages identified in this experimental GOES system. The animated displays were noted as being a definite advantage (1) in seeing a weather trend, (2) for developing an insight into weather causes, and (3) being able to observe real-time weather moving over an area (e.g., thunderstorm development).

5. What would be your requirement for optimum system trending?

Comments to this question were broad and varied. Since 21 of the 24 specialists had not had GOES training, their comprehension of the question was limited. Hence, only the responses from those with the formal training in satellite interpretation were considered. Their suggestions were for color enhancements, sectorizing, and sequencing at the local level and the availability of hardcopy, as well as machine display.

6. How does the quality of the pictures displayed in the CRT and TV monitor compare with the quality of the pictures from the Laserfax?

It was stated that when looking at a single image (picture), the quality was better than on the Laserfax. It was more difficult to determine fine shade differences on the CRT. It was suggested that a change in the CRT phosphor from green to grey (black/white) would improve the present display. The CRT picture seemed to quiver slightly, causing some eyestrain when viewed closely. It should be noted that these comments relate to individual or single picture quality, not the overall evaluation of the GOES system.

7. What is your preference as a display medium — the CRT or the TV monitor — and why?

The CRT was preferred over the TV monitor due to picture quality and resolution.

8. Does color enhance or detract from the usability of the weather product when compared to standard black and white displays?

No clear preference was made for color over black and white displays. Color provided certain enhancement, but black and white was preferred for clarity and detail. (Note: Color displays were not available for evaluation at this time. The question was posed hypothetically.

9. What other weather pictorial overlay would best supplement the information on the satellite images?

Specialists want to have an overlay capability on the GOES maps. They would like to select the type of overlay to suit the briefing requirement. Overlays most often mentioned were surface, analysis, radar summary, 200-300-500 MB chart, as well as weather producing/causing systems (highs/lows) and fronts.

10. What is your reaction to the zooming capability of the system?
What portion of the product should be displayed?

A zoom capability was favored by all evaluating specialists. It would be especially beneficial for special terrain, such as mountainous areas. It would also be beneficial for special weather situations, such as thunderstorm buildups. The preference was for the ability to zoom in on any sector of the satellite picture that was available.

11. The specialists were asked if they had a preference for sequencing rate, degree; i.e., time lapse and preferred image type (digitally enhanced infrared image or a standard visual product).

The consensus of the group indicated a medium-to-slow sequencing rate on the order of four frames per second. The choice of product was clearly for an infrared image. Finally, a clear choice of 3-, 6-, 12-, or 24-hour time lapsing could not be determined in this evaluation.

RESPONSES TO THE GOES SYSTEM FINAL INTERVIEW QUESTIONNAIRE.

1. Do you feel that the various image types and movements of those images are an aid to efficient briefing?

Of the 24 evaluators, 23 indicated the GOES images were an aid to more efficient briefings. Surprisingly, the only specialist who replied negatively was both GOES data trained and qualified and was using the products in her home facility. This specialist stated that without adequate knowledge of image interpretation, it would be difficult to use GOES products for more than general briefing or to basically self-brief.

2. Do you think that any images are excessive or redundant (such as combining visual and infrared)?

No. The group felt the two image types complimented each other and, of the two, the infrared was the better product.

3. Would this system or a similar system add to your ability to self-brief?

There was unanimous agreement that it would add to one's ability to self-brief (add to but not substitute for a complete preduty briefing). The animated system "sticks in your mind better" and as one specialist succinctly stated, "The difference is sort of like trying to explain a cartoon compared to watching an animated version of the same cartoon."

4. What comments, if any, would you make regarding the amount of information that is displayed on the screen at one time?

The information was adequate and very appropriate to specialists' needs within an FSS. Suggestions were made to add color enhancements and overlay maps. One excellent observation made regarding the information displayed was the ability, using GOES imagery, of interpreting weather between reporting points (especially thunderstorm activity).

5. If you had a zoom capability, what would be your preference; e.g., a 400- to 600-mile radius? Also, would you like this displayed; i.e., ability to select the area of the country you want?

Responses tended to be rather broad with the range of zoom capability of 200 to 1,000 miles. Specialists indicated a large range due to their specific requirements during a particular route briefing. The ability to select the area of the country they desired, and the adjustable zoom feature were features highly desired by all specialists.

6. Is there anything you want to add or comment on?

This question became an open forum during the interview, and specialists were able to respond broadly to the prototype system and the machine display of satellite imagery information. Several comments are worthy of note and emphasis:

"Satellite imagery is a tool to be used with other weather informational products for overall effectiveness. I would like to see a way to add more information to GOES products. I would like to see an overlay capability; the animation capability is tremendous. I prefer the step feature in animation because it allows you to work at your own rate. I definitely prefer a pace you can control; namely, slow speed and step forward and back. I am most impressed with the animation feature, especially for trending. I also like the "both" function. The "still" function is also good, it gives you the most current visual or infrared picture. The capabilities of the system are especially good in the summertime during thunderstorm activity and squall-line development. This is where the trending function is good; with hardcopy, the map must be passed around as needed (only one copy), and if it is misplaced, damaged, etc., everyone is out of information; but with the CRT display, GOES imagery is available to all positions, thus, a most important consideration for me in my facility."

In summary, the prototype display system was well received by all participants in this evaluation. They enjoyed and were excited when talking about the system. A persistent question they continually asked was "It's great — how long must we wait before we can have it?"

RESULTS

The synopsis of questionnaire data revealed the following specialist preferences, relating to satellite pictorial products:

1. Machine (CRT) versus hardcopy display of information.

2. Complete adequacy of the machine display in the performance of preflight briefing duties.

3. CRT highly preferred over television display.

4. No advantage of color over black and white displays (generally a neutral feeling when discussing color enhancements).

5. Digitally-enhanced infrared images preferred together with the capability to project these images at medium speed, slow speed, and individually (step feature); the speed depending on one's current requirements.

6. Need to have GOES products available at all briefing positions. With hardcopy, you just have it available at one position, and it must be handed around, thereby being subject to damage (ripped, coffee stained just where you need to see the detail, etc.).

7. Elimination of BOTH modes in the FAST forward and reverse speeds. This rapid "flip-flop" effect provided no meaningful transfer of information and proved to be a distraction to the specialist.

Animation was found to be the feature most praised and desired in utilizing GOES satellite products. As one GOES trained specialist observed, "The animated system is much better than an oral briefing. It sticks in your mind better."

Another specialist, one from an automated facility (but not GOES system trained), also stated it succinctly, "I'm most impressed with the animation feature, especially for trending. The capabilities of the system are especially good in the summertime during thunderstorm activity and squall-line development. This is where the trending function is good."

Based on the personal interviews conducted, the step feature was the second most highly desired function. This feature was preferred in animation, for both infrared and visual because it allows the specialist to work at his or her own pace. It is liked because it can be (individually) controlled (solely by the specialist). The rate can be controlled along with the direction, both forward and backward.

Special features highly praised or desired are as follows:

1. Animation

2. Update capability

3. Step sequencing

4. Area sectorization/zoom capability

5. Overlay capability; e.g., radar summary, fronts, highs and lows

6. Ability of GOES to "fill-in-the-gaps" between weather reporting points

7. Grey resolution preferred over green (background) resolution

8. Selectable zoom (100 to 600 miles) and area of country desired

9. HALT feature

Considering the responses to the final interview questionnaire and the personal interviews, the current composite evaluation of GOES imagery reveals a presently designed system fully capable of meeting the specialist's needs to perform an effective and efficient briefing. The specialist now has an additional tool to aid and enhance pilot briefings; one that is easy to learn to use, extremely fast in the transfer of information to the user, and timely in the rapid gathering and deployment of information (30 minutes from orbital source to specialist and pilot).

When added to the specialist's present methods and tools utilized in providing pilot weather briefings, GOES products were rated a significant improvement on all aspects rated when compared to no change from the present system (except for item 14, amount of eyestrain). (See figure 1.)

Animation was the single feature most desired and most highly praised in this GOES evaluation. In utilizing this tool, the specialist desired to control the speed of this animation (medium, slow, and step) to suit the current requests and requirements of the pilot briefing. Training was also found to be of critical importance in the full utilization of the GOES products.

CONCLUSIONS

Taking the position that a similar system in a real-time environment would perform at a level comparable to that of the laboratory evaluation, it is reasonable to conclude that:

1. The proposed Geostationary Operational Environmental Satellite (GOES) system was found to be an effective tool when used with other information and products for total briefing effectiveness as the statistically significant results of the T score analysis (table 2) have shown.

2. The animation capability is the most outstanding feature in the present system evaluation.

3. The step mode is the preferred speed medium when operating the system for use in pilot briefings.

4. Eyestrain was the only negative aspect identified in the evaluation of the proposed GOES system.

RECOMMENDATIONS

1. It is recommended that additional field evaluations be conducted to:

a. Sample a larger population of specialists having the required knowledge and skills,

b. Determine operational suitability and reliability of design,

c. Assess the overall attitude of the sample population towards this system, and

d. Determine the optimum enhancements required by the user.

2. Any limitations identified during the field test would allow management and project personnel to design an adaptation strategy to overcome these limitations prior to the specification and procurement phase of product development. Specifically, additional tests should be conducted to reduce the amount of eyestrain encountered in the system as presently designed.

3. Of all the aspect items addressed in this study, as well as other Flight Service Station (FSS) automation studies, "amount of eyestrain" continues to appear as a negative response, thus requiring a strong recommendation for additional test of man-machine relationship to reduce the impact of "eyestrain" with relation to automation.

APPENDIX A.

GOES SYSTEM EVALUATION QUESTIONNAIRE

1. Do you prefer machine display (as in the IPS and ARVIN systems) or hardcopy in the display of satellite weather information for use in pilot briefings?

2. Can you adequately use the machine display medium in the performance of your duties at preflight...at in-flight...at EFAS?

3. What is your reaction to the system's capability to update satellite images?

4. What is your reaction to the sequencing capability of the system; i.e., Do the animated displays assist you in weather trending?

5. What would be your requirements for optimum system trending?

6. How does the quality of the pictures displayed on the CRT and TV monitor compare with the quality of the pictures off the Laserfax?

7. What is your preference as a display medium, CRT, or TV monitor, and why?

8. Does color enhance or detract from the usability of the weather product when compared to standard black and white displays?

9. What other weather pictorial overlays would best supplement the information on the satellite images?

10. What is your reaction to the zooming capability of the system, and for what portion of the product to be displayed?

11. Please indicate by circling your response.

    a. The rate of sequencing you prefer

        1. fast (10-20 frames per second)
        2. medium (4-9 frames per second)
        3. slow (2-3 frames per second)

    b. The degree of sequencing you prefer

        1. 3-hour time lapsing
        2. 6-hour time lapsing
        3. 12-hour time lapsing
        4. 24-hour time lapsing

    c. Which do you find easier to work with

        1. Digitally enhanced infrared images
        2. standard video products

APPENDIX B

GOES SYSTEM FINAL INTERVIEW QUESTIONNAIRE

Specialist training/qualifications:

EFAS training: Yes____ No_____

Are you currently certified?_____
Approx. time used_____

GOES training: Yes_____No_____

Are you presently using these products?_____
Approx. time used_____

Automation Experience: FSS Facility_____

Manual (nonautomated)_____
Service A _____
MAPS _____
AWANS_____

1. Do you feel that the various image types and movements of those images are an aid to efficient briefings?

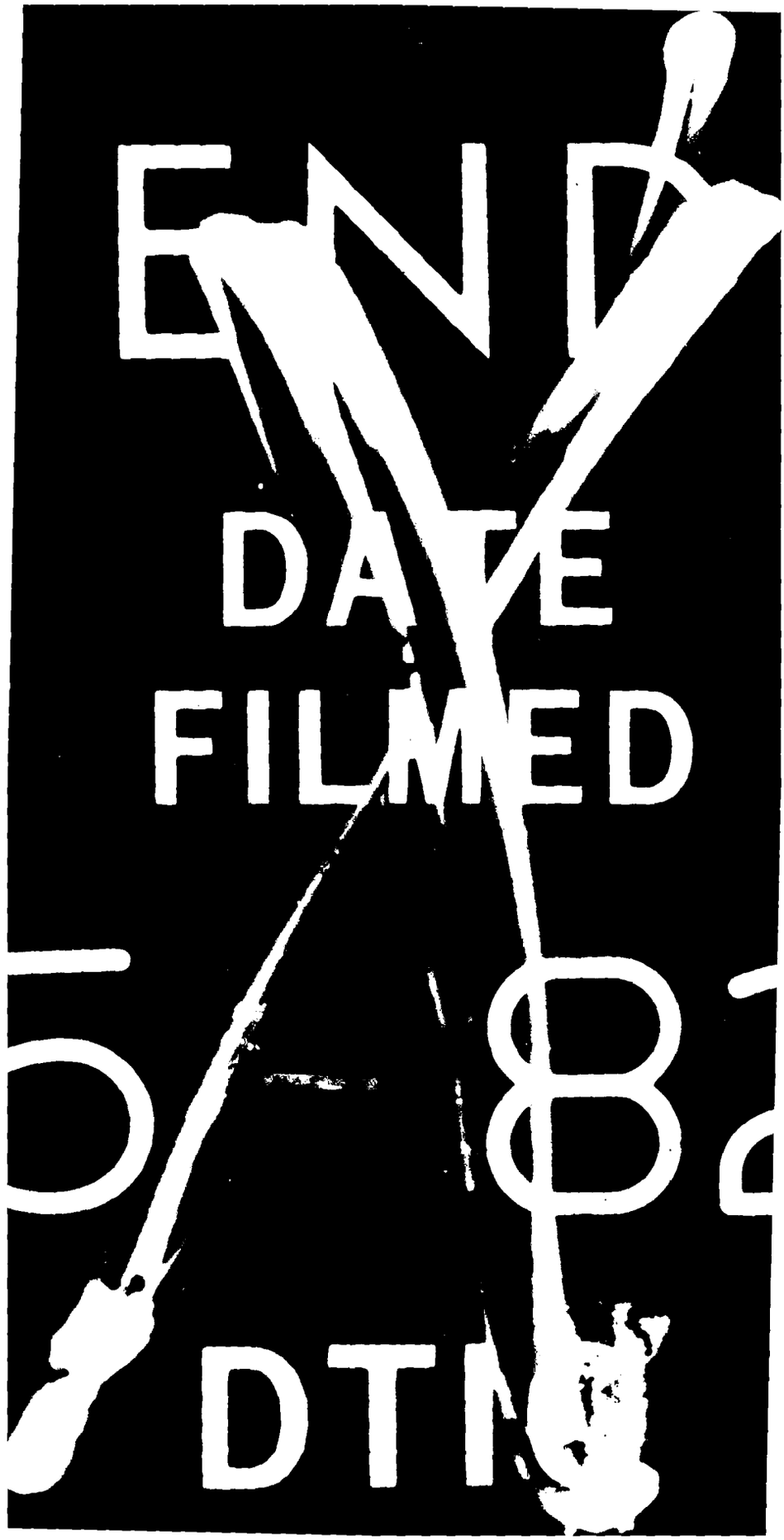
2. Do you think that any image types are excessive or redundant, such as combining visual and infrared?

3. Would this system, or a similar system, add to your ability to self-brief?

4. What comments, if any, would you make regarding the amount of information that is displayed on the screen at one time?

5. If you had a zoom capability, what would be your preferences; i.e., a 400-600 mile radius, or what? Also, would you like this displaced; i.e., ability to select the area of the country you want?

6. Is there anything you want to add or comment on?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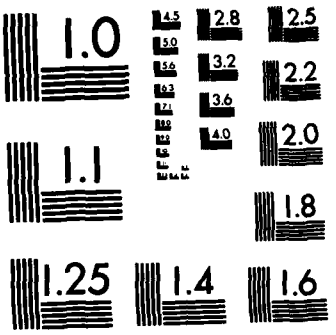

SUPPLEMENTARY

INFORMATION

AD A113 619

ERRATA

Report No. DOT/FAA/RD-82/2
DOT/FAA/CT-81/45

EVALUATION OF DISTRIBUTION AND DISPLAY SYSTEMS FOR SATELLITE IMAGERY (PHASE I)

March 1982

Interim Report

Prepared for
DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Systems Research & Development Service
Washington, D.C. 20590

REPLACE PAGES 8 and 9

Released March 1983

no a priori reason to expect deviations from the mean in only a single direction, two-tailed tests were used for all items. All questions were phrased so that careful reading would result in fair responses, thus precluding stereotype answers. Also, response categories were varied so as to minimize common sources of error, such that no response was unduly influenced by a single or overall favorable aspect when rating dimensions. That is, the form was designed so the respondents would read and respond to each item independent of the previous item or any overall attitude toward an automated system.

The strong preference for such a display system is profoundly evident from the statistical results presented in tables 2 and 3. Although the questions were phrased to include a balance of favorable or unfavorable responses, the interpreted value of the changes was positive over 93 percent of the survey. The aspect item that yielded the highest t score was item 1 (speed of data access).

SUMMARY OF RESPONSES.

RESPONSES FROM GOES SYSTEM EVALUATION QUESTIONNAIRES.

1. Do you prefer machine display (as in the IPS) or hardcopy display of satellite weather information for use in pilot briefings?

Machine display, utilizing CRT's, was the overwhelming choice as a display medium. Hardcopy had a singular benefit mentioned by several specialists; namely, increased clarity especially on the visual images. But, even with this benefit, those specialists prefer machine display when looking at the total system utilization. Pertinent comments were as follows:

"The machine display is much better suited for pilot briefings because of the looping capabilities, ease in accessibility, and simple operational codings."

"I feel the IPS (machine display under evaluation) is better suited for briefings as it is much easier to show a trend and has an easier access to weather data."

"Machine display does not have the clarity of hardcopy, particularly with visual (VI) imagery. However, advantages of machine display; i.e., "movie loop," outweigh this factor."

"I prefer a machine system. In normal situation, the hardcopies float around various positions making access difficult, if not impossible."

2. Can you adequately use the machine display medium in the performance of your duties at preflight...at in-flight...at EFAS?

Response to this question was mixed: 73 percent said "Yes;" 9 percent said "No;" and 18 percent gave a conditional, but qualified "Yes." The "no" responses were due to lack of training/familiarization associated with interpreting satellite imagery.

Responses were highly favorable at the preflight position (100 percent), especially in face-to-face briefings. Responses were somewhat negative at in-flight and EFAS. As one GOES system trained specialist said, "Real-time demands

TABLE 2. T SCORE ANALYSIS, PART I

	Aspect Item On Which Comparison Is To Be Made	Mean X	Standard Deviation SD	Standard Error SE	T-Score	Significance *
1.	Speed of data access	4.86	0.359	0.078	23.81	<0.0001
2.	Ease of obtaining data	4.67	.483	.105	15.87	<0.0001
3.	Time required to perform pre/post-duty briefing	4.48	.680	.148	9.97	<0.0001
4.	Thoroughness in presenting data for briefing	4.52	.602	.131	11.63	<0.0001
5.	Ease of extracting and interpreting information	4.38	.805	.176	7.85	<0.0001
6.	Ability to obtain and understand the overall weather situation	4.48	.602	.131	11.27	<0.0001
7.	Confidence in system	4.29	.784	.171	7.52	<0.0001
8.	Overall ability to give adequate and complete briefing	4.24	.700	.153	8.09	<0.0001
9.	Ability to self-brief prior to taking the position	4.38	.590	.129	10.71	<0.0001
10.	Time require to disseminate information	4.33	.730	.159	8.39	<0.0001
11.	Clarity of the information displayed	3.86	.964	.210	4 08	0.001
12.	Ability to adequately explain the weather	4.29	.717	.157	8.18	<0.0001
13.	Effect on integrating satellite information with other briefing products	4.43	.676	.148	9.65	<0.0001
14.	Amount of eyestrain	3.32	.885	.203	1.58	0.14
15.	Suitability of display as an information source	4.38	.590	.129	10.71	<0.0001

* Critical t at 0.05 (N=21) = 2.085
0.01 (N=21) = 2.845
0.001 (N=21) = 3.849
0.0001 (N=21) = 4.837

Critical t at 0.05 (N=19) = 2.100
0.10 (N=19) = 1.733
0.07 (N=19) = 1.925
0.15 (N=19) = 1.503
0.14 (N=19) = 1.543

TABLE 3. T SCORE ANALYSIS, PART II

	Aspect Item On Which Comparison Is To Be Made	Perceived Change	Perceived Value of Change	Rank
1.	Speed of data access	IMPROVEMENT	*	1
2.	Ease of obtaining data	IMPROVEMENT	*	2
3.	Time required to perform pre/post-duty briefing	IMPROVEMENT	*	7
4.	Thoroughness in presenting data for briefing	IMPROVEMENT	*	3
5.	Ease of extracting and interpreting information	IMPROVEMENT	*	12
6.	Ability to obtain and understand the overall weather situation	IMPROVEMENT	*	4
7.	Confidence in system	IMPROVEMENT	*	13
8.	Overall ability to give adequate and complete briefing	IMPROVEMENT	*	11
9.	Ability to self-brief prior to taking the position	IMPROVEMENT	*	5
10.	Time require to disseminate information	IMPROVEMENT	*	9
11.	Clarity of the information displayed	IMPROVEMENT	*	14
12.	Ability to adequately explain the weather	IMPROVEMENT	*	10
13.	Effect on integrating satellite information with other briefing products	IMPROVEMENT	*	8
14.	Amount of eyestrain	***	**	15
15.	Suitability of display as an information source	IMPROVEMENT	*	6

* Respondents Favor Video Display System

** NSD: No Significant Difference

*** The difference is not measurable statistically; therefore, we cannot offer any compelling evidence at this time that there is any profound difference in Item 14 relative to either system.

were not met." The greatest value seemed to be in the specialist self-briefing for an overall view of the weather trend. In addition, it was felt that GOES product could be effectively used at all positions and would augment weather graphical products; e.g., surface analysis charts.

3. What is your reaction to the system's capability to update satellite images?

Responses ranged from "very good" to "excellent." Update prior to machine display was left to comparison only. In utilizing the CRT, the movement leaves little doubt.

4. What is your reaction to the sequencing capability of the system? Do the animated displays assist you in weather trending?

The animation feature was the most highly praised feature identified in this GOES evaluation. The animation and the capability to control one's own pace utilizing the step mode were the major advantages identified in this experimental GOES system. The animated displays were noted as being a definite advantage (1) in seeing a weather trend, (2) for developing an insight into weather causes, and (3) being able to observe real-time weather moving over an area (e.g., thunderstorm development).

5. What would be your requirement for optimum system trending?

Comments to this question were broad and varied. Since 21 of the 24 specialists had not had GOES training, their comprehension of the question was limited. Hence, only the responses from those with the formal training in satellite interpretation were considered. Their suggestions were for color enhancements, sectorizing, and sequencing at the local level and the availability of hardcopy, as well as machine display.

6. How does the quality of the pictures displayed in the CRT and TV monitor compare with the quality of the pictures from the Laserfax?

It was stated that when looking at a single image (picture), the quality was better than on the Laserfax. It was more difficult to determine fine shade differences on the CRT. It was suggested that a change in the CRT phosphor from green to grey (black/white) would improve the present display. The CRT picture seemed to quiver slightly, causing some eyestrain when viewed closely. It should be noted that these comments relate to individual or single picture quality, not the overall evaluation of the GOES system.

7. What is your preference as a display medium — the CRT or the TV monitor — and why?

The CRT was preferred over the TV monitor due to picture quality and resolution.

8. Does color enhance or detract from the usability of the weather product when compared to standard black and white displays?